Board of County Commissioners
Agenda Item Summary

Meeting Date February 19, 2003
Bulk Item: Yes ☐ No ☒

Division: Board of County Commissioners
Department: **George R. Neugent**

AGENDA ITEM WORDING:

Presentation and discussion on a self-financed program to establish hurricane shelters.

ITEM BACKGROUND:

PREVIOUS RELEVANT BOCC ACTION:

CONTRACT/AGREEMENT CHANGES:

STAFF RECOMMENDATIONS:

TOTAL COST: **BUDGETED:** YES ☐ NO ☐

COST TO COUNTY: $ Source of Funds:_____

REVENUE PRODUCING: YES ☐ NO ☐ **AMT PER MONTH:** **YEAR:**

APPROVED BY: COUNTY ATTY ☐ OMB/PURCHASING ☐ RISK MANAGEMENT ☐

APPROVAL: TM for Neugent
Commissioner GEORGE R. NEUGENT
DISTRICT II

DOCUMENTATION: INCLUDED ☒ TO FOLLOW ☐ NOT REQUIRED ☐

DISPOSITION: AGENDA ITEM # 15

A STUDY REPORT

A SELF-FINANCED PROGRAM TO ESTABLISH HURRICANE SHELTERS

in

Monroe County, Florida

For presentation to the:

Board of County Commissioners

January, 2003

Prepared by:

Joel Rosenblatt, P.E.

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EXECUTIVE SUMMARY

Impact of the effects of Hurricanes Hugo and Andrew emphasized the fact that Monroe County cannot cope with a major hurricane. Since this concept was first presented, the impacts of Hurricane Georges and Mitch brought the problem closer to home. As a result of Hurricane Floyd, the fact that evacuation is not a feasible response to many hurricane threats became widely recognized as being true far beyond the parochial considerations of Monroe County.

Not only can the population not be reliably evacuated overland, but emergency shelter provisions are not only inadequate, but unlikely to be in place in time to be available where needed within any predictable future. Following "planned" overland evacuation procedures during the Andrew experience resulted in directing many people from areas where they would have been safe,- into the eye of where the storm hit. Having arrived there, they were left to drive all over the mainland (as far as Orlando and Gainesville) trying to find a place to stay. In the aftermath of Andrew, the Director of Public Safety of Dade County, after reviewing the results, stated that "overland evacuation is not a feasible approach to hurricane emergency response for all of south Florida". Nevertheless, obligatory evacuation procedures remain on the books as originally written, unchanged by repeated demonstrations of their uselessness as an emergency response.

A vague consideration of hurricane shelters had been simplistically incorporated in plans developed by the county "planning staff". While detailed plans had been developed to coordinate all the activities related to orderly overland evacuation, as mandated by state law, that same law provides that overland evacuation shall not be ordered for storms of less than category III intensity (Saffir/Simpson intensity scale). That same law states that *shelters be provided and used for the lower storm intensity categories.* However, no comparable planning for their supply had been done. The requirement had been vaguely alluded to in our planning by a statement that such facilities will be "incorporated in county capital facilities".

There it has remained. There are no such county facilities. There is no program for

developing them in any time frame. There is no need for such facilities for county government requirements to serve other local government needs. Such new capital facilities as may be planned are too constrained by budget limitations.

Under such a scenario, only a few shelter facilities would come into being coordinated with construction of future public buildings. There is no schedule for the projected number of public buildings, or their intended dispersal related to required shelter capacity and its best dispersal.

Since the two most recent hurricanes, the Secretary of the Florida Department of Community Affairs finally convened a major work study based on recognition of the futility of overland evacuation as a hurricane emergency response, and called for repeal of the state regulations requiring such plans. He recommended launching generalized shelter programs throughout all coastal areas of the state.

It is improbable that local government will ever have a need for that many public buildings of suitable capacity. It is unlikely that needed public buildings will have an appropriate dispersal among the urbanized areas of Monroe County to provide shelter access where most appropriate. It is even more unlikely that local government capital improvement budgets can support the expenditures required, from tax income sources, to construct special purpose facilities to supply shelter needs. It is equally improbable that existing capital facilities, built with no such service intended, will provide needed resistance to a storm of significant magnitude by pure chance.

To resolve this impasse related to what is a public safety matter of concern, for which the situation that occurred in Homestead and after Georges has made people recognize as real, a proposal is presented, for incorporation in the Land Use Plan, *intended to attract private equity capital* to supply such facilities, in privately built and financed buildings,- whose principal use is economically viable to the owner/developer for all those weeks and years when no hurricane emergency conditions arise.

The principal risk of loss of life in a hurricane strike is that of drowning in accompanying floods. The safest place that can be provided to avoid rising flood waters is in upper floors of tall buildings designed to resist both concurrent high velocity wind forces and flooding of their foundations and lower floors. The present height limitations of land use regulations were enacted to preclude construction of such buildings in the belief that height limitation is a simple technique for limiting development density or land use intensity.

The concept presented herein creates a procedure for attracting private capital to supply emergency shelter needs while retaining the land use intensity and density limitations intended by the land use plan. It proposes regulations to accomplish those purposes,- but without using height restrictions as the means for accomplishing them.

P R E L I M I N A R Y D R A F T - January, 2003

HURRICANE SHELTER DEVELOPMENT (HSD) ZONING

ABSTRACT:

Material presented herein is a concept for permitting construction of buildings:

a. Capable of supplying emergency refuge/shelter needs of the general public in a hurricane emergency.

b. Assuring their geographical dispersal along the island chain urban areas to make them available where and when needed, and accessible by existing local transportation facilities.

c. Offering conditions making construction of such structures sufficiently economically viable to attract private equity capital for their development.

d. Constrained by regulation to prevent creation of substantive increase in land use intensity and/or density beyond that intended by existing land use regulations.

The report details:

1. Means of attracting necessary private capital investment in terms of real estate economics affecting investment viability of the opportunities created.

2. Siting criteria best suited to assure both hurricane invulnerability and public accessibility, with minimal adverse impact on other land use concerns.

3. A draft of appropriate regulations that will assure limiting both density and land use intensity *to that permitted under existing land use regulations.*

I. BACKGROUND

Repeated efforts to develop a rational evacuation plan for the Florida Keys in the event of an impending hurricane strike have failed. Ability of the hurricane center of the National Oceanographic and Atmospheric Administration to predict the location of landfall of a hurricane being tracked, with sufficient accuracy and lead time to permit evacuation overland via the single

highway available for the purpose, is beyond the state of the art.

The chain of islands affected is too long, the road is too limited in capacity, and is itself flood vulnerable. NOAA cannot make sufficiently accurate predictions of landfall location until it is too late to evacuate the population. In many respects, efforts to conduct such an operation, once a need for it can be reasonably well-established, poses as many risks, in terms of probability of death and/or injury, as are likely to be inflicted by the anticipated hurricane strike.

Beyond the highway, in the aftermath of one of the previous major hurricane strikes, the director of public safety of Dade County observed that "overland evacuation is not a feasible response to a hurricane threat *for south Florida*". That is the assumed destination for Monroe County evacuees, and its inadequacy had been recognized before Floyd made it blatantly obvious.

In the aftermath of Hugo, renewed concerns about hurricane safety elicited suggestions that hurricane shelter capacity be incorporated in proposed public buildings. Unfortunately, the need is for more geographically dispersed shelter locations than any foreseeable need for public buildings. The need for new public buildings is oriented toward the need for housing government operations. The number of buildings needed for shelter purposes is far more than the county budget could afford for decades into the future. The suggestion that government capital facilities may accomplish the purpose offers little more than "lip service" to the nature of the problem, and has had the effect of lulling people into the mistaken belief that the problem has been addressed and is no longer a matter of concern.

The same Florida statutes that obligate planning overland evacuation for storms expected to be of Saffir/Simpson category 3 intensity or higher, also *obligate provision of a shelter program* for storms of lesser intensity when evacuation is not expected to be mandatory. Thus far, the planning department has blandly stated that county capital facilities will serve the need. Having stated that, their actual supply was left to become someone else's problem.

Several years ago, after reviewing and conducting many studies of hurricane strikes both in Florida and along other states bordering the Gulf of Mexico, Dr. Neil Frank (former director of the NOAA National Hurricane Center) proposed a concept which he referred to as his "Vertical Evacuation Plan". It was based on years of observation and evaluation of the principal causes of death and personal injury during hurricane strikes, and studies of patterns of destruction and damage by hurricanes as they make their landfalls.

The principal observations that formed the rationale for Dr. Frank's "Vertical Evacuation" concept are:

1. The primary risk of bodily harm to persons during hurricanes is the risk of drowning (i.e.-flood risk is far greater than wind risk).

2. In coastal communities, over 85% of all property damage inflicted during hurricanes

occurs within 250 yards of shore lines.

3. While accompanying torrential rainfall may exacerbate conditions, the principal source of flood damage along coastal areas results from "storm surge", the dome of water that rises from the sea surface under the "eye" of the storm system as a result of reduced barometric pressure in the "eye" surrounded by higher air pressures around the exterior storm system. This surge follows the storm under the "eye" as it moves across the ocean. Its height dissipates rapidly as the storm moves across land.

NOAA uses a storm intensity classification system (the Saffir/Simpson Hurricane Scale) under which all storms are divided into five categories reflecting their relative severity. The worst category is the Class V storm, which poses threats of upwards of 155+ mph wind velocities, and is accompanied by storm surge heights 15 to 18 feet above normal tide level. Since the storm surge is a dome of water rising from the surface of the sea, the actual level reached when landfall occurs becomes storm surge height plus or minus concurrent tide height at the time of landfall. (viz.- In the Florida Keys, where mean high tide is about 2 feet above mean sea level, a Class V storm surge arriving at high tide could create a flood level 17 to 19 feet above mean sea level. Tides in the Keys also vary along the length of the Keys, and between ocean and gulf sides.)

Above the relative surface sea level height, the matter of wave height associated with surges exacerbates risks. Wave height is affected by a series of factors including wind velocity, fetch, water depth, and shape of the bottom.

Fortunately, where the dome is at its highest (beneath the center of the "eye"), wind velocity is zero. The highest wind velocities, in a well-formed sharply defined "eye", occur around the "wall" of the "eye". The perimeter of the wall is also locus of the most violent thunderstorm activity. Across the profile of the dome curvature, there are zones where the dome, while not at its maximum at the center, may be both substantially above normal sea level with enormous concurrent wind velocities, probably conditions near the "eye wall" rather than the center of the "eye". In that region, wave height may be additive to somewhat reduced storm surge height, but together, could represent maximum flood level.

II. THE VERTICAL EVACUATION CONCEPT

The basic observation that prompted Dr. Frank to propose his "vertical evacuation" concept was that if time and opportunity do not permit geographical evacuation, the safest places for people to go is out of those places where greatest personal injury risks are known to exist. The mainland historical cry of "run to the high ground", to escape an impending flood, is a pointless bromide in the Florida Keys. The population of most of the Florida Keys lives in an area within which an elevation 5.0 above MSL is somewhat rare (Solares Hill and Mt. Trashmore ?), and land much in excess of that elevation is over 150 miles away. The only *accessible* places with an elevation high enough to be above maximum flood levels and wave heights are the upper floors of man-made structures.

The essential criterion of flood safety is height. What remains to be assured is structural adequacy of a building to survive storm exposure that is also tall enough. Similarly, suitable buildings should be sited so as to minimize exposure to maximum storm risk conditions. Such criteria can be reduced to a set of structural requirements and siting limitations.

Structurally, building foundations must be able to survive inundation and wave height impacts at or below lower levels of the building, with a concurrent wind loading upwards of 155 mph, on the portion above grade. Siting should require that it not be less than Dr. Frank's observed 200-yard distance from nearest shore line. Further criteria, oriented to the concept of "accessibility", suggest that shelters should be distributed along the urbanized areas (perhaps not closer than five miles apart),- a criterion intended to assure a shelter with reasonable accessibility on short notice to wherever population exists, but far enough apart to preclude creation of a visual "high-rise district". Such standards must assure that, under the guise of public safety, clusters of tall buildings are not built which create an urbanized visual impact on what has been intended to remain restfully quiet townscapes in the tropical islands.

Dr. Frank had observed that among all high-rise buildings that exist throughout most coastal communities in south Florida, enough can be found meeting the strength and flood resistance criteria to permit their being pressed into such service in time of need. However, such buildings do not exist in Monroe County *because they have been outlawed by existing and previous land use regulations!* To stimulate construction of such buildings, a new special set of regulations must be enacted which will permit such construction. At the same time, these regulations must be drafted in such a way that they will not permit random construction of facilities to be built in violation of the spirit and intent of existing land use planning, by masquerading in the guise of supplying a public safety need.

To permit construction to meet only the limited needs of public safety, ***but not more***, a set of very tightly drawn criteria must be prepared which not only define what must be incorporated to supply the recognized need, but which also limits its application to not more than the amounts required to supply that need. (A concurrent building need recognized as not being met by current constraints on building might also be included by requiring that some minimum percentage of residential occupancies to be constructed under the new shelter classification also accommodate some minimum percentage of "affordable dwelling units",- at least provision of employee residential units adequate to accommodate the staffs needed to operate the building types proposed.)

III. HISTORICAL PERSPECTIVE OF MONROE COUNTY CONCERNS RELATED TO TALL BUILDINGS

The original concerns that prompted establishment of height limitations in local land use regulations were two-fold. The "knee-jerk" reactions of many people not familiar with the concept of the effect of FAR limitations, are visions of collections of densely-packed wall-to-wall buildings blocking vistas, and turning the Keys into a crowded Miami suburb.

To the average citizen, a tall building means "high-density" land use and "urbanization" of paradise. As the Keys began to show signs of increased development pressures, efforts were made *to lower maximum height restrictions,*- from 44-feet to 35 feet. Apparently, it was believed that by hiding buildings below tree lines, even though there were increasingly more of them, we could pretend they really weren't there. Furthermore, the general belief was that by designating a lowered height limitation, construction of third stories that might accommodate higher densities in multi-family units might be prevented. It might also constrain illicit enlargement of single family houses into multi-family units by internal sub-division, thereby accommodating increased density, - if there were fewer floors available on which to do it.

At about this same time, minimum flood level heights, as mapped by the Federal Emergency Management Administration (FEMA), became a part of building code requirements. Between the two, a trend had been established which, were it to continue, involved progressively lowering maximum building heights and progressively raising minimum floor levels. (Were both trends to continue, perhaps ultimately no one much over five feet tall could fit in a building without stooping, and a height limitation for people becomes implied.)

Since then, the set of associated FEMA regulations that were adopted did, in many areas, raise minimum floor levels.

In many large older cities of the United States, areas of block-after-block of low-rise buildings built decades ago, packed the available land. In many instances, these areas have become centers of large urban slums. Such areas are among the highest density residential facilities to be found anywhere in the United States,- and they are entirely within height limitations imposed by Monroe County building regulations (thought by some to represent a way of minimizing land use intensity).

By contrast, there are also examples of tall impressive buildings standing isolated in park-like settings, beautifully surrounded by fountains and landscaping which, for the size tract of land on which they have been sited, represent a haven of visual relief from the more congested impact of block-after-block of low-rise single-family housing developments.

This is particularly true when the apparently "preferred" form of single-family housing is of the "tract housing" type (the concept being maintained by inference in most residentially zoned areas incorporated in present land-use regulations). Rigorous uniformity of set-back and height regulations associated with present zoning regulations results in all buildings being lined up monotonously: same width, same height, and same volume,- all spaced in regulated uniformity. By the 1960's, after a decade of this type of post-World War II development had been experienced, the refrain of a popular song summarized general public disillusionment with the ultimate effect, "-and they're all made of ticky-tacky, and they all look just the same..."

Peculiarly, in insisting on rigorous enforcement of such constraints, many of those objecting in principle to height, regardless of whether or not it represents high density or land use intensity,

do not realize that the same density and FAR in an eight-story height results in more open space, more undisturbed habitat, lower cost of distribution of public utilities, more available recreational space, etc. The approach is generally known as "cluster type development" and originated as a reaction to "tract-house-all-in-a-row" forms of single family housing which totally consume all available land area.

Nearly thirty years later, after the error had long been recognized in professional literature in the field, "ticky-tacky" remains the obligatory form defined in Monroe County and Key West land use regulations.

If those objecting to high rise buildings can learn to understand the benefits of permissible ***density*** rather than permissible height, it is possible that they may also find their personal safety, in times of a hurricane emergency, is also better served. Such re-thinking will require sound and persistent re-education. In the rethinking process, people should be exposed to factual alternatives: i.e.- availability of additional areas of open space habitat that could be created by rearranging lateral sprawl of low-rise residential units in a vertical format; and visual relief from row after row of little boxes, -even if that variation only happens at most, once every four miles.

Another protection to the populace lies in the fact that access by the numbers of people to be served is assured by the minimum site size, while a maximum size has also been provided to assure that shelter needs do not become the mechanism for launching precisely the sort of development concentration that is a matter of concern to many residents of the community. Not only has a maximum allowable floor area content been provided, but if used to accommodate residential units, the maximum residential unit content has been specified; and if used for a hotel/motel occupancy (tourist density), the maximum number of guest room accommodations has been specified. All are proportioned to the size of sites in a way that actually increases the open space remaining beyond what might have resulted had a HSD project not been created.

Other than density concerns, there has been a concern for blocking and obstructing the view of the sea, again a fear derived from visions of row-after-row of high-rise condos and hotels along beaches, blocking the view and ocean breezes from everything landward of the buildings.

The proposed regulations specifically preclude such developments from being considered. Shelter projects must be located at sites removed a substantial distance from shore lines. Placed toward the center of the urbanized land mass, there is no view of the ocean blocked by a tall structure. The building is not between people and the sea. People are between the building and the sea. Whatever the view of the sea might have been before, will remain after construction of the HSD's are in place.

On many of the Keys, it will be difficult to find suitable parcels of land located far enough from shorelines to meet requirements where the island is not wide enough. These areas may become dependent on being served by sites on the nearest large islands, presumably able to be found within four miles.

It is essential that consideration of concepts presented not be taken out of the complete context within which they have been developed ! Dashing off with trivial information that "they want to permit high-rise buildings", without including the content that prevents things making "high-rise" anathema a call to arms,- become appeals to fear rather than reason. Unfortunately, "sloganeering" has historically (or perhaps hysterically) had more mob appeal.

The fact that a high-rise may also be means of preventing loss of hundreds of lives as a result of "Hugo-II", "Andrew,Jr.", or "Floyd-B" tracking across the Keys ought not be lost in hysteria. Homo sapiens is also entitled to protection as a species. Hugo and Andrew were simply recent examples of the fact that it can happen here. While Georges was a lesser storm and Mitch had been dissipated before crossing the Caribbean to hit the Keys, Mitch had been a major storm when it hit the south side of the Caribbean. We are not prepared with an adequate means of survival should a comparable storm pass this way.

Can the worst prospects envisioned by images of "monstrous" buildings poking up from the middle of our islands, five or more miles apart, be more horrendous to contemplate than the prospect of hundreds of bodies floating around among the debris after a solid hit by some future storm ? Realities of such a prospect must be faced. The storm must come sooner or later. There is no high ground.

IV. DESIGN CRITERIA FOR VERTICAL SHELTER PROJECTS

A. Special Structural Requirements for Buildings

First concern is that of assuring performance of shelter functions of buildings under assumed hurricane conditions. To guarantee that performance, a special set of structural requirements, some of its special purpose contents, and some of its building materials requirements must be stipulated. Special needs to be supplied for this purpose may go beyond requirements of building codes applicable to other buildings in general, but actually, recent upward revision of basic building code requirements for wind load resistance, and flood plain elevations defined by FEMA, have already established a relatively safe set of building standards for all new buildings being built in the Keys..

In any tall building, regardless of reference design "base wind speed" , it should be understood that the reference is specifically wind speed at a point thirty feet above the ground surface. (This has been defined as fastest wind sustained for one mile with a recurrence probability of once every hundred years. Since Andrew, the reference criterion was changed to one based on maximum short term gust velocity. Both generally result in similar strength requirements.) Starting from ground level reference, buildings must be designed for increasingly higher wind velocities as their heights increase, *in accordance with existing building code formulae* that result in increasing "base wind" loading exponentially with height.

Here in the Keys, when the "basic wind speed" was 110 mph, use of a 30 pound-per-square-foot horizontal wind loading thirty feet above the ground was required. At a height of 100 feet above the ground (i.e.- the height of a ten-story building), *that same base wind load reference* required use of a horizontal wind force applied to the structure of 42 pounds-per-square foot. (Recently, with adoption of a gust speed criterion, the basic wind speed became 150 mph, and that produces a ***force*** of 57 psf as the basic reference design wind speed .today.)

The public is aware of reports from NOAA giving estimated wind velocities during the course of tracking a hurricane event, ***but is not familiar with the differences in use of terminology in a NOAA tracking report and the use made of "base wind speed" in a building code !***

As hurricanes are first observed by NOAA (usually by satellite imagery), and before the "eye" has been sharply defined, there is a procedure, substantially subjective, for "estimating" probable peak wind velocity present *anywhere* in the storm system. (At this early stage, despite existence of a statistical methodology being used, the same data presented to seven different "experts" at the NOAA hurricane center, will result in seven different estimates of maximum wind velocity.)

As the storm becomes better organized, starts approaching the American mainland, and indicates a likelihood of making a North American landfall, assistance is asked from the Air Force to fly into the storm to make in situ measurements with instruments carried aboard for the purpose. Depending on flying conditions, these flights may be made at altitudes of 15,000, 5,000 or 1,500 feet (maximum wind velocities, along the "wall of the eye", are also in the most violent thunderstorm activity, and may preclude ability of aircraft to fly there). Based on these direct wind velocity and barometric pressure readings, methodology for computing probable maximum wind velocities becomes less subjective, and accurate estimates are feasible. Velocities reported are "worst case" as measured. In general, "worst case" winds may occur anywhere up the "wall", and may also extend for a considerable distance up and down the "wall", depending on concurrent presence of up or down drafts associated with the wind velocities recorded.

By contrast, "basic wind speed" as defined in a building code is based on the statistical probability of occurrence of a wind velocity ***as measured by an anemometer sited 30 feet above the ground at a weather station***. Beyond that, an entire series of calculations are prescribed for increasing the loading resulting from the force exerted by such a wind velocity, as the height above the ground increases from that basic wind speed reference elevation.

The combination of minimum central barometric pressure and maximum wind velocity have contributed to evolution of the Saffir/Simpson hurricane scale. The worst category defined, the category V storm, has only been recorded hitting the United States four times in the history of hurricane record-keeping (one of those is an assumed value). First was the Labor Day storm that hit the Keys in 1935. Second was Camille that hit the Gulf coast in 1969. The third was hurricane Gilbert which was actually a category III storm when it crossed through the Antilles. It built up to

category V intensity (160 knot wind velocity) just before landfall in Yucatan, and then dropped back to category III intensity before its North American landfall on the coast of Texas.

The most damaging of recent hurricanes that hit the American mainland (until Andrew) was Hugo. Hugo swept across St. Croix with sustained 120-knot winds, dropped to 110 knots across Viejes and Puerto Rico, rose to 140 knots east of the Antilles, and, after veering northward, struck the coast of South Carolina with a velocity of 120 knots. The damage it inflicted was not because of its unusually high intensity classification, but because of the extent and kinds of buildings in its path. (Localized gusts, as distinct from sustained winds, may have exceeded the sustained winds reported. Hurricanes commonly spawn small area tornadoes within the areas they cover.)

The track of Floyd, straight up along the entire southeast coast of the United States, and with just barely under a category V wind velocity (155 mph), led to the virtual inundation of much of the east coast of the country.

None of these wind speed reports have anything to do with references to maximum wind thirty feet above the ground! The lowest of those reported by aircraft reconnaissance were measured at altitudes higher than any building ever built. A fifteen-story building is only one tenth the height of the lowest aircraft altitude employed in making airborne measurements during hurricanes. It is important that those making recommendations of what specified design base wind speeds in a building code should be are fully conversant with what happens to those recommendations as used by structural engineers in designing tall structures under related provisions of building codes.

Nevertheless, to avoid debate as to the severity of the storm for which criteria should be established, additional wind loading has been specified in the draft of special code requirements presented hereinafter. The fact that the historical maximum greater-than-155 mph design wind speed within the definition of a category V storm was not used is due to the author's familiarity with both the Saffir/Simpson scale **and** building codes.

B. Special Site Requirements

The second set of requirements defines special siting concerns, both in terms of minimizing storm exposure risks, and assuring accessibility in time of need. These assure removal from shore line proximity, and assurance of access by good paved roads.

The third requirement, is imposition of maximum density limitations provided in terms of floor area ratio (FAR) constraints,- to achieve the security offered by maximum height, while constraining density in a multi-storied form. To obtain maximum storm effect security, construction of maximum permissible floor area *at as high an elevation as possible* is encouraged. At the same time, it is recognized that the taller the building, the higher design wind loading will

become, and the higher the cost per square foot of building floor area will be.

A distinction must be kept in mind between needs of a "shelter", and needs of a "refuge". Storm duration itself may come and go in a matter of a few hours, and at most, less than a day. Needs of providing a "refuge", a place of sanctuary where people can go to wait out passage of storms, may be rather easily met by a building strong enough to endure the fury of the storm, suitably located for the population involved. Accessibility for such purposes is reasonably assured by requirements that HSD facilities be geographically dispersed along the island chain. Red Cross *refuge* criteria for Monroe County recommend a 10 s.f. per person floor area for *refuge* capacity determination.

By contrast, needed "*shelter*" requirements must be capable of providing minimal "housing" functions, for a more extended period of time, for those whose normal "housing" (as it had existed before the storm) may be wiped out or rendered unusable by damage wrought by the storm. It is to be expected that several days may elapse between passage of a storm and the time that outside emergency relief can be mobilized to provide needed longer term accommodation for those in need of on-going "*shelter*". Experience demonstrated by the impact of "Hugo" in the Carolinas emphasized the distinction. Conditions following the Andrew disaster were significantly worse. While the population of the Keys is smaller, the means of bringing outside relief may be more difficult and possibly exacerbated to the extent that overland highway access to the area may be destroyed by the storm.

Accessibility of "*refuge*" requirements can be maximized by assuring lateral dispersal of shelter facilities along the island chain. Many of those who seek "*refuge*" in facilities can be expected to simply return to wherever they came from after the storm passes. Those living in houses built to comply with FEMA regulations and the new Florida State Building Code requirements, should have no difficulty returning to their houses. Structures may have suffered building damage due to flying debris, but much will probably remain useable for all but the most improbable of storm intensity categories.

However, accessibility to support "*shelter*" requirements may be quite different from one area of the county to the next depending on the locus of storm landfall. A strike in the lower Keys may not interfere with overland access in the upper Keys. A strike in the upper Keys may leave both airport and port facilities in Key West intact. In other words, some "*shelters*" may be needed to serve for an extended period of time, while others might not. Red Cross *shelter* criteria for southeast Florida have been reduced to 15 s.f. per person. (In most other parts of the United States they require 40 s.f. per person.)

In either case, it is to be expected that most of those arriving at such havens will probably arrive by some sort of vehicular conveyance. Provision of extensive parking capacity will be a major consideration both at or on the sites themselves. Nearby open spaces may be pressed into emergency use for overflow parking purposes, including areas where the risk of inflicting property damage in the process would be secondary to the purpose of providing human safety.

Beyond siting requirements related to assurance of the intended public safety function, additional constraints must be clearly provided to prevent abuse of that intent. For these reasons, both maximum and minimum project sizes have been incorporated in the regulations proposed. Projects smaller than the minimum needed should be disallowed since such projects will fall short of supplying needs and will ultimately defeat the purpose of the plan by preventing one large enough to supply those needs from being built close enough thereafter. Projects larger than maximum would automatically fall into the "abuse of intent" category.

C. Special Building Content Requirements

Having provided siting considerations needed to get the populace safely inside, it is to be expected that as storm intensity builds, and flooding starts developing, most forms of public utilities will be disabled. Electric and telephone utility pole lines will be destroyed or broken, water distribution lines will be ruptured, and all will remain out of service for an extended period of time following the storm. Well water supplies may have been flooded and contaminated. Cistern supplies may have been contaminated if they were overtopped by the surge.

The refuge/shelters will therefore be obligated to maintain a safe potable reserve of water stored at an elevation above flood risk, with a capacity to support the designated number of evacuees for a designated number of days as a building criterion for such facilities. (Again, there are Red Cross criteria for daily emergency water requirements per person.) In-house emergency electric power generating capability, of an amount calculated to maintain essential services within the building for a designated period of time, together with the fuel storage capacity needed to operate that generating capability for that time, becomes another essential element of project requirements.

Some of these requirements are already part of existing building code requirements for emergency purposes. Tall buildings dependent on elevator transportation are already required to possess emergency stand-by power capability to keep one elevator operating in event of a power outage, primarily for use of emergency services (fire and ambulance). What may be new is the additional requirement that these emergency facilities be situated above risk of flooding at hurricane flood levels.

Within the buildings, accommodations for the number of persons expected to be in the building during the period of the storm must be assured. The nature of these accommodations must be determined on the basis of the estimated number needing "refuge" (as previously defined), and the number needing "shelter" for an extended period of time. These criteria have already been established, and are readily available by reference to Red Cross and Monroe County Office of Emergency Management. In general, needed criteria can be converted to specifics in terms of: number of square feet of floor space per evacuee accommodated; minimum sanitary facilities; food service capabilities; etc. In summary, it is apparent that appropriate criteria must be established for structural requirements of the building; for a unique set of siting requirements; for special facilities required within the buildings; for minimum distance between sites to assure geographic dispersion

in the county; and special off-site requirements related to access from existing paved streets and transportation facilities. In addition, guarantees must be incorporated in the project to assure delivery of public safety facilities expeditiously, while retaining the population density limitation intent of the land use regulations (themselves largely justified by expressions of concerns for hurricane evacuation lead time).

N.B.- Similar criteria have already been applied to building the new jail on Stock Island and county services building in Marathon, based on the need to keep them in service *without evacuation of the occupants* during a storm emergency.

V. ECONOMIC FEASIBILITY

The construction of buildings meeting such unusual requirements will be expensive. Several additional facilities that must be incorporated will also add to the cost of projects without having a useful non-emergency value commensurate with those additional costs. In granting the right to commandeer the building, or designated special purpose shelter facilities within it, an owner is encumbering an additional risk not faced by investing in more conventional development opportunities.

To be sufficiently economically viable to attract private investment willing to supply the public needs described, projects must also offer opportunity for a developer, to warrant acceptance of all premium costs and risks, to realize a greater benefit by undertaking such a project than he finds offered by alternative investment opportunities.

Under conditions that must face realities of development economics, reviewers must keep in mind that at a point at which constraints are unnecessarily imposed, beyond those necessary *to accomplish the intended purposes,* incentive to participate can be destroyed. Thus, opportunity to supply a public need *that cannot be supplied by a public expenditure* will be destroyed.

Everyone dealing with this concept must recognize, at the outset, that the needed balance will not result from adoption of inflexible postures whose consequences have not been thought through. Both advantages and risks must be considered *and assigned relative weights* before any rational judgement of economic feasibility can be formulated. Other forms of variances, being sought or granted under existing regulations, are pursued to obtain an advantage for the owner or developer. In this case, granting requests for a development in accordance with this new proposed set of regulations, is supplying a recognized life-threatening community protection not otherwise being addressed.

Ultimately, assigning relative weights must be judged against available alternatives. Developers of such projects must see an opportunity to use the building profitably, when it is not

called upon to perform shelter functions. Such usage must be so attractive, in terms of return on investment, that it will more than justify the premium costs that must be encumbered in its construction.

An understanding of several significant considerations related to the economics of buildings and those of real-estate development is extremely important to one attempting to make rational judgments about regulations intended to accomplish widespread public purposes at private cost.

A. Elevator Economics

As soon as a proposed building becomes four stories or taller, building codes require that it be equipped with elevators. The minimum size of those elevators must be large enough to accommodate a stretcher and its attendants. Since elevator shafts create chimney effects, which could become means of fire spread, they must be isolated from the rest of the building by fire rated protection. They also consume shaft floor area on each of the floors served, which contribute a reduction of total "net rentable floor area" made available for use in the building.

Elevators designed to serve most buildings are classified in three groups: 1- geared; 2- low-speed gearless; and 3- high speed gearless. The cost of these machines becomes greater as one moves from consideration of one category to the next. Essentially, their costs increase with increase in speed and capacity. Planning vertical transportation systems for tall buildings becomes a critical element of planning entire building projects. They can be the single most important component determining economic feasibility limits since their costs, pro-rated to total useable floor area, can immediately be seen to represent the most expensive component incorporated in the building.

In planning a vertical transportation system, both occupancy of floors served and height of building dictate the number and size of elevators, and their operating speed requirements. The analyses required to plan vertical transportation is similar to the way horizontal traffic dictates number of traffic lanes that must be incorporated in planning a highway system,- and its design speed. The significance of the impact of this sort of analysis can be seen in what has happened over the years to the classification of building types.

The economics of elevator requirements have given rise to categorizing of "mid-rise" buildings and "high-rise" buildings. Mid-rise buildings are almost uniformly eight stories high (one rarely sees a modern building being built six stories tall). High-rise buildings are almost uniformly fifteen stories tall. ("Skyscrapers" are a special case.) In both of these cases, at these heights an optimum relationship is reached between the cost of the elevator *type* that can serve that number of stories and its *size* by the square-footage per floor that can be served by an elevator of that type and size.

The maximum height building that may be built without elevators is the three-story or